Earth as an Exoplanet: Determining the Rotational Period and Presence of Clouds from Photometric Simulations

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Future observations will aim to determine the surface and atmospheric properties of extrasolar planets similar to the Earth. Here, we have modeled changes in the apparent brightness of the Earth (as a function of its phase angle, and in the direction of the observer's) due to the rotation and orbital motion of the Earth, as well as to the temporal variability of clouds and ice (on daily and seasonal timescales). We apply reflectance models that have been previously validated with observations of the Earthshine that illuminates the dark side of the Moon. We use real cloud data from satellite observations to characterize the hourly, diurnal, and seasonal variability that we might observe in earth-like extrasolar planets. We find that measuring the rotation period of the Earth is non-trivial, even for high signal-to-noise observations, largely due to the temporal variability of cloud cover on timescales comparable to the rotation period. If the rotation period can be measured, then deviations from a periodiic signal can be used to infer the presence of tracers (relatively short-living structures) in its atmosphere (i.e., clouds). This could provide a useful technique for recognizing exoplanets that have weather (i.e., cloud cover changing on a diurnal timescale). Such variability is likely to be related to the atmospheric temperature and pressure being near a phase transition. Thus, such observations could support the possibility of liquid water on an extrasolar planet